Lockheed Martin Aeronautical Systems
86 South Cobb Drive Marietta, GA 30063

DEPT. OF TRANSPORTATION

00 MAR -7 PM 12: 10

LOCKHEED MARTIN

73743

L00M0135
1 March 2000

U. S. Department of Transportation
Dockets, Docket No. FAA-1999-6411 -17
400 Seventh Street SW
Room Plaza 401,
Washington DC 20590

Subject: Lockheed Martin Aeronautics Company comments to Notice of Proposed Rulemaking regarding Transport Airplane Fuel Tank System Design Review

Reference: (A) FAA NPRM No. 99-18, Docket No. FAA-1999-6411

Enclosure: (a) Lockheed Martin Aeronautics Company - Lockheed L-188 Electra Fuel System Safety Study dated February 24, 2000

Dear Sirs:

These comments are submitted in response to Notice of Proposed Rulemaking No. 99-18, Docket No. FAA-l 999-6411 regarding Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements.

In general, Lockheed Martin supports the intent of the proposed rulemaking to improve fuel system safety of aging aircraft, Lockheed Martin has been participating with the Federal Aviation Administration and the Air Transport Association in investigating fuel system designs and service experience on the operating fleet of aircraft, primarily those models still engaged in revenue service. Reviews of the Lockheed Martin L-101 1 and Series 382 aircraft are planned.

As proposed in Notice of Proposed Rulemaking 99-18, the Special Federal Aviation Regulation (SFAR) and amendments to Part 91, Part 121, Part 125 and Part 129 of the Federal Aviation Regulations, apply to transport aircraft receiving an original type certificate after January 1, 1958. This effectivity date based on the date of type certification would require that the Lockheed Martin L-188 Electra comply with the proposal since its initial certification date is August 22, 1958. Lockheed Martin has conducted a study of the L-188 as described in the attached report and has concluded based on that study that imposing these new requirements on the Electra will not improve safety nor be cost-effective. This conclusion is based on a review of the cost analysis presented in the NPRM, the number of Electra aircraft operating, the Electra's design, safety record and a number of other considerations described in the attached repot-t. Lockheed-Martin requests that the proposed regulation be changed to exclude the L-l 88 Electra from its applicability.

FAA's economic analysis of the cost of the design review proposed in this NPRM is based on a fleet wide consideration. This approach results in a per aircraft cost basis that does not appear unreasonable. However, the expense to Lockheed Martin to perform the design reviews and prepare service documents will be the same as for other manufacturers that have twenty or thirty operators and hundreds of operating aircraft. FAA's cost benefit analysis identifies an engineering effort to perform the design review and preparation of documents as taking from three-quarters to three person years to perform.

The SFAR proposal would require that a safety review be conducted to determine if the subject design meets the latest amendment level of FAR 25.901 and a new set of requirements in FAR 25.981. The Electra was certified to Civil Air Regulation (CAR 4b) which has no requirement similar to FAR 25.981 regarding fuel tank temperatures or the demonstration that ignition sources will not result from all combinations of failures not shown to be extremely improbable. This will require new analysis and possibly testing to prove that the design meets the requirement for all operating conditions. If such analysis were not successful a redesign would be necessary. Redesign would increase the expense considerably.

FAR 25.901 is also significantly more complex than the regulations originally applied to the Electra. Since the methods of analysis were different during certifications conducted 40 years ago, the effort to show compliance with the new regulations defined in the SFAR and to prepare that documentation suggested in proposed Advisory Circular 25.981-1x Fuel Tank Ignition Source Prevention Guidelines will likely exceed the maximum FAA estimate of 3 person years. For an aircraft such as the Electra, the time to familiarize a new staff with the design, to locate pertinent files, to relate those files to the long history of the aircraft and to develop test and compliance documents for new regulations are time-consuming tasks that will add significant costs to FAA estimates

If the analysis noted above shows that the design does not meet the newly imposed requirements, redesign will be necessary. Such redesign would increase the expense by a factor of 3 to 5 depending on the detail. It would also increase considerably the expense to the operator of installing the new design.

The FAA in the NPRM preamble notes that reciprocating powered transport airplanes were excluded from the SFAR because their small number and advanced age would make it impractical from an economic standpoint. Lockheed Martin suggests that the L-188 Electra also falls into this category and should be treated in a similar fashion by excluding the Electra from the rules applicability. In general, it is suggested that the retroactive application of the new requirements to any older model include provisions in the rule that would permit favorable service experience to be substituted for extensive failure analysis.

In support of the Lockheed Martin position proposed herein, that the new regulations not apply to the Electra, a study of the Electra system has been prepared (Attachment 1). In summary, the Lockheed L-188 Electra Fuel Systems Safety Study shows that the Electra fuel system service experience is excellent. The report contains data supporting the following.

- The L-I 88A was type certificated on August 22 1958 and 170 L-I 88's were built between 1958 and 1961. Two models were produced, the L-I 88A and the L-I 88C. The C model, type certificated on July 10,1959, incorporated various structural improvements to accommodate a weight increase for the aircraft of 3,000 pounds. In forty plus years of operation the Electra fleet has accumulated on the order of 6 million flight hours. Lockheed Martin records on the Electra fleet indicates that of the 170 aircraft produced there are 30 aircraft still operating throughout the world. Of these, 13 are operating in the United States.

- The thirteen aircraft in the United States are operated by Zantop International Airlines, Reeve Aleutian Airlines in Alaska and Renown Aviation of Santa Maria, California. Reeve Aleutian and Renown are each operating three aircraft. Zantop, headquartered in Ypsilanti, Michigan, is operating six aircraft. Most of these aircraft are involved in cargo-only operations. Renown has one aircraft configured for charter passenger operations. Reeve Aleutian has one passenger configured aircraft and two combi (passenger/cargo) configured aircraft. The other aircraft is a public aircraft operated by the National Center for Atmospheric Research.

- A design review shows that there are very low voltage Fuel Quantity Indication System wires within the fuel tank. Because of the low voltage used in the system these wires will not be an ignition source. The use of a surge tank and a scavenge pump results in the boost pumps being covered with fuel at all times. Keeping the pumps covered with fuel reduces the risk of a pump being an ignition source if a failure produces heat or sparks. In addition the boost pumps and scavenge pumps have thermal shut off switches for further protection against heat in the fuel tank. All electrical lines are protected by circuit breakers. In the 6million hours of worldwide fleet operation in a wide variety of operating environments there have been no accidents or safety problems with the fuel system.

- Review of approximately 2200 L-188 Service Difficulty Reports from 1986 to present and Lockheed service information documents since 1958 found no reported discrepancies with fuel system components. This record shows that the fuel system design is a robust design with an exceptional service record. This service experience provides ample indication that the design is sound and that further failure analysis of the system would not be cost effective. Advisory Circular 25.981-1A suggests that a failure analysis be prepared for the fuel system. Preparation of such a report would be extremely costly since all employees that worked on the Electra have long since retired and details of the design and associated design analysis are difficult to find. Lockheed Martin suggests that the actual demonstrated service record is a much better indicator of safe design than a paper analysis at this point in time.

- Review of the Airworthiness Directives issued on the L-188 series of aircraft over the years does not indicate any pattern of unsafe conditions created by weakness in the design of the fuel system or the electrical system.

- Review of the accident history of the L-188 series of aircraft shows that while there have been 51 aircraft hull losses due to a variety of causes, no losses have been attributable to the fuel system, fuel system wiring or fuel system fires. One accident in which there was a structural breakup due to overload in a storm also resulted in a wing fire possibly related to a lightning strike. Considering the extreme circumstances of this situation, this event does not point to a design weakness in the fuel system.

- Wiring systems are particularly susceptible to damage if disturbed during maintenance or modification. Pulling wire bundles apart and disturbing connectors and wire bundle supports could result in damage that would be difficult to observe but could pose serious problems at a later time. The alternative would be replacement of all wiring and supports which would be extremely costly and not be cost effective in view of the Electra fleet's 40 years of safe fuel system operation.

Based on these various reviews Lockheed Martin believes that the Electra fuel system has demonstrated safe operation for 40 years and that additional regulations are not needed for continued safe operations of the small remaining fleet for the remainder of its operational life.

Lockheed Martin appreciates the opportunity to comment on the Notice of Proposed Rulemaking. We will be happy to provide further details. If there are any questions, please contact the undersigned at 770-494-3052.

Sincerely,

R. J. Trusis, Manager
Airworthiness

RJT:jcm

Lockheed Martin Aeronautics Company

Lockheed L-l 88 Electra
Fuel System Safety Study

February 24, 2000

Table of Contents

History of L-188 Design and Manufacture

The Lockheed Martin L-188 is a four -engine turboprop aircraft designed to carry up to 99 passengers. It was designed and built by the Lockheed California Company in Burbank, California. Production started in 1957 and continued until 196 1 with 170 aircraft being produced. Two different models were produced the L-188A and the L-188C. The later model incorporated structural improvements to increase the takeoff weight from 113,000 to 116,000 pounds.

Considering that a majority of the aircraft produced are over 40 years old, a large number of the 170 aircraft originally produced have been dismantled, destroyed, placed in museums or otherwise taken out of service. Lockheed Martin records maintained on the fleet show that 30 aircraft are still in service and flying through out the world. Of that world population there are 13 still in operation in the United States. See Table 1.

Reeve Aleutian Airlines in Alaska and Renown Aviation of Santa Maria, California each are operating three aircraft. Zantop International Airlines headquartered in Ypsilanti, Michigan is operating six aircraft. Most of these aircraft are involved in cargo only operations. Renown has one passenger configured aircraft for charter operations. Reeve Aleutian has one passenger configured aircraft and two combi (passenger/cargo) configured aircraft. The other aircraft is a public aircraft operated by the National Center for Atmospheric Research.

Table I

Lockheed L-188 Electras Flying

SERIAL	MODELNUM / UPDATEDATE	REGISTRAT	FLYING / COMMENTS	OPERATOR	OPLOCATION	HOURS	LAND
1110	L188C 30-Sep-99	N289F	Y	Renown Aviation	US	71302	38016
1033	L188A 06-Jan-00	N5522	Y	Zantop	us	48245	42699
1036	L188A	N351Q	Y	Renown Aviation	US	42843	37918
1038	L188A 06-Jan-00	N344HA	Y On lease to Traffic Management Corporation	Zantop	us	50555	49277
1043	L188A 06-Jan-00	N346HA	Y On lease to Traffic Management Corporation	Zantop	us	51854	48445

1084	L188A	N282F	Y	Zantop	us	62192	24418	06-Jan-00	Landings since Zantop acquisition
1109	L188C	N340HA	Y	Zantop	us	45686	30466	06-Jan-00	On lease to Traffic Management Corporation
1112	L188C	N360Q	Y	Renown Aviation	US	34449	31832	04-May-99	
1130	L188C	N308D	Y	NCAR	us	24000	20200	11-Oct-99	~300 hrs/yr
1140	L188A	N9744C	Y	Reeve Aleutian	us	53294	43279	09-May-99	
2010	L188C	178RV	Y	Reeve Aleutian	us	76112	35998	03-Nov-99	Forward 40% fuselage from S/N 2001
2007	L188C	N1968R	Y	Reeve Aleutian	us	43982	21151	23-Apr-99	
1146	L188A	N286F	Y	Zantop	us	62847	26199	06-Jan-00	Landings since Zantop acquisition

1091	L188C	G-CEXS	Y	Channel Express	UK	52275	50500	07-Jan-00	
2014	L188C	G-FIZU	Y	Atlantic Airlines	UK	61555	34579	22-Nov-99	
1068	L188A	G-CHNX	Y	Channel Express	UK	45874	48275	07-Jan-00	
1075	L188C	G-OFRT	Y	Channel Express	UK	51098	48854	07-Jan-00	
1138	L188C	G-FIJR	Y	Atlantic Airlines	UK	53562	44012	22-Nov-99	
1100	L188A	G-LOFC	Y	Atlantic Airlines	UK	40977	31208	22-Nov-99	
1144	L188C	G-LOFE	Y	Atlantic Airlines	UK	41710	44724	22-Nov-99	Former Hunting Cargo EI-CET
1143	L188A	G-LOFD	Y	Atlantic Airlines	UK	48958	21718	22-Nov-99	
1129	L188A	G-FIJV	Y	Atlantic Airlines	UK	57076	46949	22-Nov-99	Former Hunting Cargo EI-HCE
1131	L188C	G-LOFB	Y	Atlantic Airlines	UK	41213	40382	22-Nov-99	
1006	L188A	C-FVFH	Y	Air Spray	Canada	33425	21525	28-Jan-99	"~200 hrs/year, Tanker #89"

1063	L188A	C-FQYB	Y	Air Spray	Canada	54850	58745
	28-Jan-99	"~200 hrs/year, Tanker #88"					
1060	L188A	C-FZCS	Y	Conair Aviation	Canada	53053	44700
1039	L188A	OE-ILB	Y	Amerer Air	Austria	62562	47870
	09-Jul-99	RR Sep 98					
1145	L188A	OE-ILA	Y	Amerer Air	Austria	47503	20723
	11-Dec-97						
1102	L188A	5-T-1	Y	Argentine Navy	Argentina	35972	32211
	01-Dec-95						
1072	L188A	6-P-104	Y	Argentine Navy	Argentina	34495	
	01-Dec-95	Landings not reported					
1070	L188A	6-P-103	Y	Argentine Navy	Argentina	37858	36401
	01-Dec-95						
1120	L188A	5-T-2	Y	Argentine Navy	Argentina	31506	
	01-Dec-95	Landings not reported					

Fuel System Design

The Electra fuel system design is a simple and easy to maintain system of four integral tanks within the straight wing. Each tank supplies an engine. The fuel-feed and crossfeed system is purposely designed to prevent fuel being transferred from one tank to another, but it does allow any tank to supply any combination of engines, one of which will normally, but not necessarily, be the corresponding engine. A scavenge system in each tank ensures that nearly all fuel is usable.

Tank fuel is supplied to the engine by a tank boost pump in each tank. The tank boost pumps supply two independent engine-driven high-pressure pumps, which normally operate in tandem. The fuel pumps, screens, and filter throughout the fuel system are provided with bypasses so that failure or blockage will not interrupt engine fuel. A heat exchanger, located upstream of each engine's fuel control, utilizes warm engine oil to heat the fuel flow as necessary to maintain it at an optimum temperature, well above the freezing point of water. A capacitance type fuel quantity system indicates the weight of fuel in each tank on individual indicators. Fuel flow to each engine is measured by a mass type flowmeter and indicated in weight of flow per hour. Pressure switches installed at key points operate advisory lights to inform the crew of immediate or potential trouble in the fuel system. Fuel can be jettisoned from the left wing tanks, or the right wing tanks, or all tanks simultaneously through a mechanical manually operated fuel dump system.

Fuel Tanks Boost Pumps and Fuel Tank Scavenge Pumps

Located in the aft-inboard comer of each fuel tank is an open top surge box, with a flapper check installed at the deepest point of its forward wall (the lower inboard comer). All fuel for engine feed is taken from this surge box. The flapper valve will trap enough fuel in the box to sustain the engine for a short period of time if an airplane maneuver should cause fuel to surge forward and/or outboard when the fuel level in the tank is low. The surge box will not hold enough fuel to sustain the engines for a long period of nose-down flight that may occur in a descent. To provide for such a contingency each tank has an a-c motor powered centrifugal type scavenge pump, which draws fuel from the forward inboard comer of the tank and spills it into the surge box. Some aircraft have an alternate design in which the fuel boost pump and the scavenge pump are combined into one unit.

An a-c motor driven boost pump is mounted in each surge tank box. A quick-disconnect between pumping element and discharge casing enables the pump to be easily removed. Pump element removal is done through access panel on top of the wing. Pump wiring is routed through a conduit from the pump to a junction box on the rear wing spar. This conduit is sealed so that fuel does not enter the conduit or touch the wires within. A thermal switch that opens at approximately 358 degrees F. is incorporated in the pump to protect it from hazardous overheating. This could occur if the pump were operated dry or if the impeller should become jammed. The probability of the impeller becoming an ignition source due to jamming or running dry is remote, since there is a surge tank with a scavenge pump in each tank. Together they assure that the boost pumps will be covered at all times to cool any heat generated in the pump and to maintain a non-flammable mixture over the pump.

The scavenge pumps are mounted in the tank on the front wing beam to pump fuel into the surge tanks. A heat exchanger for cooling the hydraulic fluid is installed in the pressure line of each inboard tank. The inboard scavenge pump operation is controlled independently of the boost pump, but the boost pump cannot be operated without the scavenge pump. The outboard pumps operate simultaneously with the boost pumps. Each pump has a thermal switch which opens at approximately 307 degrees Fahrenheit incorporated in the pump to protect it from hazardous over heating, which could occur if the pump were operated dry or the impeller should become jammed. The pump must be removed to reset the switch once activated. The wiring for the scavenge pumps is entirely outside the fuel tank.

Fuel Quantity Indication System

The Electra uses a capacitance type fuel quantity indication system. It consists of transmitters installed in the tanks, transistorized amplifier-indicators on the main instrument panel and indicators on the refueling panel at the aft end of the no. 3 nacelle. Conduits in the tank contain the wiring to the transmitters. The wiring passes through the rear beam at feed-through connectors. This type of system is extremely sensitive and operates at millivolt levels in all wires running through the fuel tank. There are five quantity transmitters in each outboard and two (three on extended range aircraft) in each inboard tank. The inboard transmitter in each tank contains a fuel deviation index (FDI) compensator to compensate for changes in the fuel dielectric constant.

Conduits within the tank protect the wires. The conduits are not sealed so they provide only physical protection against movement or damage from sloshing fuel. Multiple transmitters within the tank are wired in series with two connecting wires. Electra electrical drawings indicate these wires are to be treated as a sensitive harness and segregated by engine and tank numbers. By definition, sensitive wires are not to be grouped with any other wires of any other category but wires of the same category could be grouped.

One wire running between in tank transmitters is currently identified as M27500-20RC-1S06 wire. This wire is manufactured under specification MIL-C-27500G. Original Electra drawings-- 823421 note 3-- call for Suprenant Wire, Type 1AS-WTE-1932-JN. This wire is no longer available. The M27500-20RC-

1S06 is the current replacement wire. The designation defines a wire constructed as follows: The -20RC portion of the part number indicates a 20 gage wire core consisting of 19 strands of 32 AWG (wire gage) copper twisted and covered with an extruded Teflon jacket, thereby forming one wire per MIL-W-22759/11. The (-1S) indicates that the inner wire is covered with a braided silver-coated copper shield. The (06) indicates that the entire wire and shield assembly is covered with a minimum of two contra-helically-wrapped polytetrafluoroethylene (PTFE or Teflon) tapes, which are sintered to form a homogeneous wall. The color of the single outside jacket is white and identified with the part number.

The second wire is Minneapolis Honeywell wire type MH6057DS symbol DY indicating that this is a silver-coated copper wire with extruded Teflon insulation.

Since this system operates at such a low voltage these wires are not considered an ignition source,

Fuel Tank Pilot Valve

Electra fuel tanks also contain a pilot valve located near the top of each tank that is used in the refueling process and will automatically close the refueling valves to prevent overfilling the fuel tank if the normal shutoff switch is not actuated. Electrical connections for a solenoid on the pilot valve, which connect to the refueling panel, are routed through the fuel tank in a dry conduit to the aft spar. The system is a 28-volt DC system and is only energized during the refueling process. Two in-series switches must be thrown to supply power to the system. Since this system is not activated in-flight it would not present an in-flight ignition source hazard.

Electra Fuel System Safety Features

The Electra fuel system design contains a number of features that improve safety from a fuel-tank ignition source standpoint.

1. The only high voltage lines in the fuel tank run from the aft wing spar tank wall to the boost pumps. The wire is protected from damage by a conduit in the run between the boost pump and the outside of the fuel tank.

2. The use of a surge tank with a scavenge pump in each tank insures that fuel boost pumps will always be covered with fuel. The fuel, acting as a heat sink, will absorb heat generated by any pump motor or impeller failure and reduce the chances of the temperature reaching an ignition point. Maintaining fuel above the pump also reduces the chances of any heated surface being exposed to a fuel air mixture that could possibly ignite. The design is further protected by a thermal switch that will shut down any boost pump that overheats to a

temperature of 358 degrees Fahrenheit well below the auto ignition temperature of a Jet A/air mixture.

3. Scavenge pump wiring is located outside of the fuel tank and the tank is protected from an overheating scavenge pump, in a similar fashion to the boost pump, by a thermal overheat switch that will shut down the pump if its temperature exceeds 307 degrees Fahrenheit.

4. The fuel quantity indication system wiring in the fuel tank operates at a voltage well below the 40 volts FAA has noted as less than that required to create sparks in Draft Advisory Circular 25.981-1x.

5. The pilot value used during refueling operations is a 28-volt DC solenoid with wiring protected by a conduit. Both the refueling access door switch and a refueling panel switch must be activated to energize this circuit. It is not activated during flight so it is not an in-flight ignition source.

Review of FAA Service Difficulty Reports (SDR) , Lockheed Service Bulletins, Lockheed Service Information Letters, and Lockheed All Operator Letters

Lockheed Martin has reviewed the FAA's Service Difficulty Reports (SDR) database for the L-l 88 Electra for the time period 1986 to present. Of the approximately 2200 reports in the database there are no reports of discrepancies in the fuel system itself. There are reports of fuel leaks due to structural problems but there are no reports of problems with fuel quantity indications, electrical wires connected to the fuel system, fuel pumps or fuel lines.

Lockheed Service Bulletins, Lockheed Service Information Letters and Lockheed All Operator Letters issued since 1958 have also been reviewed. None of these documents have any information indicating that design or procedural changes were needed to correct problems with the fuel system, the fuel quantity indication system, the electrical wiring associated with the fuel system, the fuel pumps or fuel lines.

Safety Analysis

Since there are no Service Difficulty Reports from 1986 to date or Lockheed service information documents since 1958 indicating discrepancies with fuel system components, it appears that the fuel system design is a robust design with an exceptional service record. This service experience provides ample indication that the design is sound and that further failure analysis of the system would not be cost effective. Advisory Circular 25.981-1A suggests that a failure analysis be prepared for the fuel system. Preparation of such a report would be extremely costly since all employees that worked on the Electra have long since retired and details of the design are difficult to find. Lockheed Martin suggests that the service record is a much better indicator of safe design than paper analysis.

Review of Airworthiness Directives

Lockheed Martin's review of the Airworthiness Directives listed below has not found any corrected unsafe condition that relates to the fuel tank safety concerns described in Notice 99-18. Neither is there a pattern of conditions that would indicate a weakness in the design of the fuel system or the electrical system.

The following Airworthiness Directives pertaining to the Lockheed L -188 Series aircraft have been issued

.

AD Number:	AD Subject:
59-21-02	WING LEADING EDGE SCREWS
59-25-04	GENERATOR FEEDER WIRES
60-01-05	PROPELLER DEICING
60-01-06	WING SURFACE PLANKS
60-03-05	TAIL PIPE COWL
60-04-03	LORD ENGINE MOUNTS
60-09-03	OPERATING RESTRICTIONS
60-10-05	FUEL PRESSURE RELIEF VALVE
60-11-03	COWL LONGERONS
60-13-03	FUELING PROCEDURE CHECK
60-20-03	ELECTRICAL SYSTEM
60-20-04	LAVATORY DRAINS
60-24-01	FUEL PRESSURE RELIEF VALVE
60-25-02	AILERON COUNTERWEIGHT
60-26-04	SWIRL STRAIGHTENER SCOOP
60-26-05	ELEVATOR AND BOOST CONTROL VALVE
61-09-01	ELEVATOR HYDRAULIC DAMPER HOUSING
61-15-04	SAFETY BELT GROMMETS
61-21-05	COMPASS CIRCUIT BREAKERS
62-26-04	ELEVATOR BALANCE WEIGHT ARMS
63-08-03	DEBOOST CONTROL SYSTEM
63-17-03	HORIZONTAL STABILIZER SPAR WEB
63-18-03	FUSELAGE STRINGERS
64-11-03	UPPER WING PLANKS
64-12-05	LANDING GEAR CAM FOLLOWER
64-14-05	MAIN LANDING GEAR SUPPORT FITTING
64-16-04	AILERON PUSH-PULL TUBES
65-09-04	UPPER WING PLANKS
65-15-04	NO 4 WING PLANK DRAIN HOLES
65-16-01	NOSE LANDING GEAR SUPPORT LINK
65-21-05	VERTICAL STABILIZER ATTACH CHANNEL
66-04-02	WING PLANK SPLICE AREAS
66-05-03	OUTER WING CAP FITTINGS
66-11-02	LOWER WING PLANK SPLICE AREAS
66-28-04	NOSE LANDING GEAR STEERING HOUSING
67-03-06	LANDING GEAR DOOR CYLINDERS
67-11-04	FUSELAGE MAIN FRAMES FORGING
68-11-02	CRACKS IN UPPER & LOWER WING PLANKS
68-23-05	UPPER WING PLANK CRACKS
69-08-07	CRACKS IN LOWER WING SURFACE
69-26-08	TAKEOFF WARNING SYSTEM

74-25-04	HORIZONTAL STABILIZER
77-21-09	AILERON/RUDDER JAMMING
80-10-05	WING FRONT SPAR CAPS
80-12-01	CARGO DOOR MODIFICATIONS
81-03-53R1	FUEL LEAKAGE
81-24-09	FAA APP REV AFM PERFORMANCE REDUCTION
87-08-03	AIR START DOOR
87-16-05	STRUCTURAL INTEGRITY
89-14-03	FLAP UNIVERSAL JOINTS
97-20-02	POWER LEVERS
98-24-25	ANTI ICE OPERATIONS

Details of any of these AD's can be found on the Internet at the following address http://www.tc.gc.ca/aviation/ad/mm.

Review of Accident Investigations

A review of the accident records for the L-188 Electra shows that 5 1 aircraft have been lost due to a variety of causes but no accidents have been attributable to the fuel system or fuel system wiring. One accident in which there was a structural breakup due to overload in a storm also resulted in a wing fire possibly related to a lightning strike. Considering the extreme circumstances of this situation, this event does not point to a design weakness in the fuel system.

Date	Airline	Location	Fatal /Onbd	Accident Cause
02/03/1959	American Airlines	East River, N Y	65(72)	Crew error during back course ILS
09/29/1959	Braniff Airways	Buffalo, TX	34(34)	Structural failure-Prop whirl mode
03/17/1960	Northwest Orient Airlines	Cannelton, IN	63(63)	Structural failure-Prop whirl mode
09/14/1960	American Airlines-	New York, NY	0(76)	Failure to plan and execute proper approach
10/04/1960	Eastern Air Lines	Boston, MA	62(72)	Multiple engine fail due to bird impacts
06/12/1961	KLM Royal Dutch Airlines	Cairo IAP, Egypt	20(36)	Pilot inattention
09/17/1961	Northwest Orient Airlines	Chicago, IL	37(37)	Mechanical failure due to improper maintenance
08/06/1962	American Airlines	Knoxville, TN	0(72)	Pilot error in heavy crosswind
03/27/1965	Air New Zealand	Whenuapai, New Zealand	0(6)	Gear failure after heavy landing
04/22/1966	American Flyers Airlines	Ardmore, OK	83(98)	Pilot incapacitated during approach
02/16/1967	Garuda Indonesia Airways	Menado, Indonesia	22(92)	Hard landing at unusual airport
05/03/1968	. Bran iff Airways	Dawson, TX	85(85)	Structural failure in heavy turbulence
02/05/1970	Varig	Porto Alegre, Brazil	0(0)	Gear failed when a/c landed short
08/09/1970	LANSA	Cuzco, Peru	99(100)	Loss of control after engine failure

08/24/1 9 70	Universal Airlines	Ogden-Hill AFB, UT	0(3)	A/c returned to rwy after liftoff
12/24/19 71	LAN SA	Puerto Inca,Brazil	91(92)	Fire in wing due to lightning led to structural failure (LAC disagrees with this conclusion, overstress only)
01/09/19 72	Air Manila International	Manilla, Philippines	0(0)	Write-off
03/19/19 72	Universal Airlines	Ogden-Hill AFB, UT	0(3)	Prop failure? Fire
08/27/1 9 73	Aerovias Condor	Bogota, Colombia	42(42)	Hit terrain on takeoff
10/30/19 74	Panarctic Oils	Rea Point, Canada	32(34)	Hit terrain 2 mi. short of rwy.
11/06/19 74	Reeve Aleutian Airways	Anchorage, AK	0(0)	Hanger fire
12/1 l/l 9 74	Fairbanks Air Services	Deadhorse, AK	0(3)	Loss of control due to improper procedures
04/30/1 9 75	Zantop International Airlines	Deadhorse, AK	0(3)	Wing failure due to hard landing
07/1 O/l 9 75	Aerovias Condor	Bogota, Columbia-	2(4)	Lost altitude after liftoff, hit ground
03/12/19 76	Great Northern Airlines	Udrivik Lake	0(3)	Ground loop on icy runway
06/04/1 9 76	Air Manila International	Adana,Philippines	45(45)	Engine failure on takeoff, hit terrain
07/02/19 76	Eastern Air Lines	Boston-Logan IAP, MA	0(0)	Bomb
03/31/19 77	Nordair	CFB Summerside, Canada	0(0)	Another aircraft ran into Electra
06/30/19 77	Cooperativa de Montecillos	Bocas del Toro, Panama	4(4)	Missing over Atlantic Ocean
07/06/1 9 77	Fleming International Airways	St Louis-Lambert IAP, MO	3(3)	Lost control on 3 engine takeoff
01/05/1 9 79	Great Northern Airlines	North Slope,AK	0(15)	Landed short of runway
11/18/19 79	Transamerica Airlines	Granger,UT	3(3)	Lose of power, crew disorientation, in-flight breakup

02/02/1980	TACA International Airlines	San Salvador,	0(3)	Ground fire, bomb suspected
01/08/1981	SAHSA	Guatemala City, Guatemala	6(6)	3-engine ferry, lost hydraulics and a/c control
03/21/1982	Zantop International Airlines	Macon, GA	0(0)	Hanger collapsed
05/30/1984	Zantop International Airlines	Chalkhill, PA	4(4)	Lost of control due to instrument failure
01/09/1985	TPI International Airways	Kansas City, KS	3(3)	In-flight stall
01/21/1985	Galaxy airlines	Reno,NV	70(71)	Crew failed to monitor flight path during a/c
01/29/1985	Galaxy Airlines	Marietta-Dobbins AFB, GA	0(3)	Gear jammed, fire during wheels up landing
11/30/1985	Mandala Airlines	Medan-Polonia, Indonesia	0(45)	Gear failure, fire during wheels up landing
02/05/1986	GLM Aviation	Kasongo-Lunda, Congo	2(14)	Forced landing
09/12/1988	TAME Ecuador	Lago Agrio, Equador	7(7)	3 engine ferry -Lost 2nd engine and crashed
09/04/1989	TAME Ecuador	Taura AFB, Equador	0(99)	Gear up landing
09/24/1989	Argentine Navy	Trelew, Argentina	?	Fire following 2 gear landing
03/21/1990	TAN Airlines	Las Mesitas, Honduras	3(3)	Hit mountains during approach
07/14/1990	TPI International Airways	Oranjestad-Reina Beatrix Airport, Aruba	0(3)	Prop failure caused damage to 2 other engines.
01/21/1994	Trans Service Airlift	Kinshasa, Congo	0 (?)	Nose gear collapse
03/13/1995	Blue Airlines	Kinshasa-N'Djili APT, Congo	0(?)	Landing
12/18/1995	Trans Service Airlift	Kahengula,Angola	141(144)	Crashed on takeoff due to overload

02/08/1999	Blue Airlines	Kinshasa, Congo	7(7)	Crashed on takeoff
03/01/1999	Channel Express	Shannon, Ireland	0(6)	Gear up touchdown, go around & land with one engine